INFRA INGUINAL BYPASS IN SINGLE TIBIAL VESSEL OUTFLOW-EARLY OUTCOMES

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DECLARATION

I solemnly declare that this dissertation **"INFRA INGUINAL BYPASS IN SINGLE TIBIAL VESSEL OUTFLOW-EARLY OUTCOMES"** was prepared by me in the Department of Vascular Surgery, Government General Hospital, Madras Medical College, Chennai under the guidance and supervision of **Prof.T.VIDYASAGARAN**, M.Ch., Professor & Head of the Department, Department of Vascular Surgery, Government General Hospital, Madras Medical College, Chennai. This dissertation is submitted to the Tamil Nadu Dr.MGR Medical University, Chennai in partial fulfillment of the University requirements for the award of degree of M.Ch., Vascular Surgery.

Place : Chennai
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CERTIFICATE

This is to certify that this dissertation entitled **"INFRA INGUINAL BYPASS IN SINGLE TIBIAL VESSEL OUTFLOW-EARLY OUTCOMES"** is a bonafide record of the research work done by **Dr.C.SARAVANAN ROBINSON**, for the award of M.Ch., Vascular Surgery, under the supervision of **Prof. T.VIDYASAGARAN**. M.Ch., Professor & HOD, Dept. Of Vascular Surgery, Government General Hospital, Madras Medical College, Chennai. I also certify that this dissertation is the result of the independent work done by the candidate.

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INTRODUCTION

In Chronic Limb Ischemia, Infrainguinal bypass surgery is the mainstay of therapeutic interventions aimed at limb salvage. The outcome of surgery is the chief determinant of limb salvage and is affected by many factors. Those factors can be modifiable factors and non modifiable factors. Since 1949, when Kunlin introduced the femoropopliteal bypass graft with saphenous vein, several centers have reported their results. Patency rates at 30 days have varied from 76% to 96%[1]. Cumulative five-year patency has varied from 60% to 76%[1].

Patients with limb-threatening arterial ischemia and extensive tibio-peroneal occlusive disease challenge the vascular surgeon. Several reports have documented acceptable patency rates, limb salvage, and operative mortality with arterial bypasses to the ankle and foot. Results are similar to grafts to the tibial and peroneal vessels. In spite of these, the procedures have not gained widespread acceptance. Standard arteriography often does not demonstrate arterial anatomy of the ankle and foot. Operations are tedious and lengthy. Surgical technique must be meticulous. For these reasons, skepticism has prevailed. Major amputation is often offered as a primary mode of therapy.

Graft thrombosis in the early postoperative period represents a failure for both patient and surgeon. The causes for the graft failure involve both patient factors and technical factors. It is believed technical errors at the time of operation account for early failures and some cases of late failure in long follow up, and there is general agreement that technical factors account at least for early failures. The patency rates have been related to clinical severity of ischemia, run-off, diabetes and diameter of vein. Some authors report an adverse effect of diabetes on patency whereas others report no adverse effect. Some believe clinical severity of ischemia influences graft failure whereas others believe the severity of ischemia has little to do with patency. Some

believe failure is more likely in the present of poor run-off whereas others believe run-off does not affect early patency. Most authors believe small veins are apt to occlude.

Graft failure rates of up to 25% have been described and in the graft failure patients more than 50% suffer a major amputation their first year. In general, limb loss in the early post operative period is about 10% and the perioperative mortality rate is 4% in infrainguinal bypass surgery.

This study is planned to review the factors that will influence the outcome of infrainguinal bypass in patients with single tibial vessel outflow and to identify those factors that are modifiable, which will help in improving the outcome of the procedures and improve the patency of the graft and limb salvage rate.

AIM

To assess early postoperative outcomes in patients undergoing Infrainguinal bypass surgery with Single Tibial artery outflow and to study the factors affecting outcome

METHODS AND MATERIALS

- Retrospective study
- Case records and angiograms of patients who underwent femoropopliteal bypass procedures and tibial artery bypass procedures with single tibial vessel outflow on angiograms were studied
- Period : 2 years from August 2005 to July 2007
- **records analyzed with respect to outcomes of**
    - immediate in hospital graft patency
    - limb salvage
- **Factors studied**
    - Age and sex distribution
    - Etiology – Atherosclerosis / Thromboangiitis obliterans / Vasculitides
    - Clinical presentation – critical limb ischemia (extent of tissue loss) / functional limb ischemia (severity of claudication)
    - Co morbid factors – diseases such as Diabetes Mellitus / Systemic Hypertension / Coronary Artery Disease with specific reference to LV function / previous cerebral infarction / history of tobacco abuse
    - Pre operative ABI and clinical level of occlusion

- **Angiogram details**
    - Site of occlusion
    - Distal reformation
    - Runoff of tibial artery, pedal arch outflow
    - Angiographic runoff score
- **Operative details**
    - Surgery done
    - Inflow vessel site
    - Inflow vessel wall / disease
    - Outflow vessel site
    - Outflow vessel wall / disease
    - Runoff
    - Conduit used
        - If GSV used – quality, diameter
    - Sequential bypass if any
- Post operative details

        - Category improvement
            - Rest pain relief
            - Ulcer healing
            - Ankle brachial index
        - Wound complications
        - Further interventions, if any
    - Final outcome – limb salvaged / major amputation required
        - Condition at discharge

Inclusion criteria

- Patients who underwent infrainguinal bypass surgery whose angiograms showed single tibial vessel outflow.

Exclusion criteria

- Infrainguinal bypass surgery with angiogram showing more than one tibial vessel outflow
- Infrainguinal bypass done as part of sequential bypass with proximal outflow disease correction.

The angiographic runoff was studied and reported as per the angiographic runoff scoring

system described by the SVS/ISCVS committee report[2]. The runoff score predict the outcome of the bypass surgery. The scoring for angiogram for the single tibial vessel bypass as follows

As this study evaluated the single tibial vessel outflow as the other two arteries are occluded they carry a weightage point of 2 and their were occluded in their the length throughout which individually carry resistance value point of 3 so the total weightage score of 6 point and plus 1 point to correct the decimal point a total of 7 point. To start with a good single tibial vessel flow had a score of a minimal score of 7, in which outflow vessel had a stenosis less than 20% in its length. The score increases with length of stenosis in the single tibial artery taking the score to a maximum of 9.5 which has an occlusion of more than 50% of its length in a poor outflow.

Weight age points

Distal anastomosis	**3**	**2**	**1**
Popliteal above-knee Popliteal below-knee	Distal popliteal		Anterior tibial Posterior tibial Peroneal
		Distal tibial	Pedal arch
Anterior tibial		Distal tibial	Pedal arch
Posterior tibial Peroneal		Pedal runoff	Collaterals to anterior and posterior tibial arteries
Pedal/inframalleolar			

Resistance value point of runoff arteries (total of three units)—occlusion

Degree of occlusion	3	2.5	2	1	0
Major runoff vessels	Occluded throughout of length	Occluded less than ½ stenosis visible collateral	50% to 99% greatest stenosis	20% to 49% greatest stenosis	Less than 20% greatest stenosis

Grading of outcome

Grading of the outcome is primary important goal of this study. The use of an ABI change of atleast 0.10 is the accepted evidence of hemodynamic improvement, to guard against the fallibility of basing success on symptomatic improvement alone. To provide an objective basis for claiming "improvement" and for defining "hemodynamic success" or "failure" and for a claim of patency, an ABI change of 0.10 has been used. The adhoc committee that originally developed these standards believed that a difference of 0.10 was sufficient to signify true change, if combined with categorical clinical improvement to define hemodynamic success or failure. The term" hemodynamic failure" has been used to indicate a lack of significant hemodynamic improvement (i.e., an increase in ABI) in spite of a patent revascularization[3].

Outcome reporting

Various outcomes can be used in the measurement after treatment including patency, limb salvage, clinical status, and quality of life. Scientific article should accept patency rates that are based on objective evaluation[3].

+3	Markedly improved	No ischemic symptoms, and any foot lesions completely healed; ABI essentially" normalized" (increased to more than 0.90)
+2	Moderately improved	No open foot lesions; still symptomatic but only with exercise and improved by at least one category; ABI not normalized but increased by more than 0.10
+1	Minimally improved	Greater than 0.10 increase in ABI" but no categorical improvement or vice versa (i.e., upward categorical shift without an increase in ABI of more than 0.10)
0	No change:	No categorical shift and less than 0.10 change in ABI
-1	Mildly worse	No categorical shift but ABI decreased more than 0.10, or downward categorical shift with ABI decrease less than 0.10
-2	Moderately worse	One category worse or unexpected minor amputation
-3	Markedly worse	More than one category worse or unexpected major amputations

Scale for gauging change in clinical status

The above said method of reporting system was followed in this study to follow uniformity in the reporting standard. In this method of reporting a combination of the clinical method and segmental pressure index were used to assess the patient's clinical improvement or deterioration. This categorizing of the result is useful in grading of the outcome in the same way for all the patients and useful in assessing clinical success in the follow up period.

A graft is considered to have **primary patency** if the graft is uninterrupted;i.e, there was no intervention such as transluminal dilation and distal extension from graft[2]. Dilation or minor revisions performed for the anastomotic or graft thrombosis or other structural defect before

occlusion do not constitute exception in defining primary patency because the procedures were intended to prevent graft failures. The outcome of these graft after intervention are called as **assisted patency**[2]. The patencies of the grafts restored after occlusion by thrombolysis or thrombectomy with or without anastomotic revision or graft reconstruction is called as **secondary patency**[2].

PATIENT PROTOCOL

All Chronic Ischemia patients were admitted in the ward, detailed history was taken. Specific complaint of the patient was recorded; those include discolorations, gangrene and ulcer, the duration of the compliant. Modes of onset of the problem such as spontaneous onset or following trivial trauma, the duration of the illness, were recorded. History of Intermittent claudication was recorded. Claudication derived from the Latin word “Claudicatio” means “limp” usage means to discomfort or disability associated with exercise depends upon the level of occlusion and extent of arterial occlusion. The patient may present with buttock and thigh claudication calf or forefoot claudication either singly or contiguous combination. The most common presentation is calf claudication, easily recognized as cramping pain in the calf that can be consistently reproduced by the same level of exercise and that is completely and quickly relieved by rest

This symptom of claudication was detailed in the history to rule out other causes for leg pain. Site of claudication, claudication distance and relieving factors were recorded.

Detailed history other illness in these patient such as transient ischemic attacks, cerebrovascular accident, chest pain their character of pain, radiation of the pain, abdominal pain if present aggravating factor, relieving factors, relation to food habit was also recorded. Tobacco usage history was also recorded such as age at which the habit was started duration of the habit form of tobacco being used, such as oral chewing, snuffing or smoking. Cigarette or

beedi smoking was also recorded.

Detailed history of presence of other systemic illness such as Diabetes Mellitus, Systemic hypertension, Ischemic heart disease, Cerebrovascular accidents was taken. Duration of the illness, treatment for the illness, and their present status of the illness were also recorded.

The patient was examined in a systematic manner, general examination, examination of other systems, and examination of the peripheral vascular system in detail In general examination such as pallor, lymphadenopathy and other finding also recorded cardiovascular system examination include clinically heart rate, volume of pulse are recorded. Fibrillating heart, congestive cardiac failure, undetected systematic hypertension, isolated diastolic hypertension are look for in specific. Cardiac condition is optimized before surgery.

Respiratory system examination is done in detail. The respiratory sounds are examined to look for any signs of bronchiostasis, tuberculosis. Respiratory reserves status with the help of respiratory physicians also assessed. The patients are prepared for surgery with respiratory system optimized with chest physiotherapy and breathing exercises.

Abdominal examination was done; it should consist of more than brief palpation for an occult aneurysm. An abdominal bruit may provide a clue of aortoiliac disease in a patient with a buttock and thigh claudication because there may be no sign of chronic ischemia and femoral pulses palpable in such patient previously palpable pulse disappear with exercise

Ischemic ulcer are usually painful with ischemic rest pain in the distal forefoot occurs nocturnally and relieved by dependency. Ulcer first has irregular edges in chronic ulcer punched out ulcer commonly over the dorsum of foot or toes may occasionally be pretibial ulcer. The ulcer base usually consists of poorly developed grayish granulation tissue. The

surrounding skin may be pale or mottled with chronic ischemic changes. Usually sign of inflammation will be deficit due inadequate circulation thereby the healing itself. These ischemia ulcers may be of spontaneous origin or might be triggered by trivial trauma. For this was the symptom they seek medical attention.

Peripheral pulse examination is the vital part of examination for vascular patients. The peripheral pulses were palpated in the specific location for the specific artery. Femoral pulses palpated with hip are externally rotated and the vessels are palpated over the pubic ramus of the Ilium, word which lies 1 $^{1/2}$ -2 finger breaths lateral to pubic tubercle. Palpation of the popliteal pulses is difficult even in experienced examiner usually palpated holding the patient in supine position with the patient knee is partial flexed the examiner hand is positioned so that the proximal interphalangeal joint hooks the tendons while the fingertips sinks gentle into the middle of the popliteal space is as effective as the palpating in the prone position. The posterior tibial artery is palpated in the hollow behind the medial malleous and the dorsalis pedis pulse is palpated along the dorsum of the foot between the first and the second metatarsal bones which is absent in 10% of the normal persons in such cases the lateral tibial artery, the terminal branch of the peroneal artery, should be sought higher in the foot, just below the ankle and medial to the bony prominence of the fibula.

Sign of chronic ischemia such as wasting of the calf muscles & thigh muscles, loss of hair growth over the toes and foot, thickening of the toenail secondary to slowness of nail growth, advanced signs of ischemia such as atrophy of the skin and its appendage and the subcutaneous tissue becomes shiny, scaly and skeletonized.

Intervention for the peripheral artery disease should be designed to treat the physiologic rather than the anatomical defect. So the physiological assessment is part of the examination. In that measurement of pressure has distinct advantage over the flow measurement for indentify

the presence of arterial disease and for assessing its severity. The pressure measurement made more reliable by augmentation of the blood flow through the stenotic segment by exercise and other methods. Measurement of systolic pressure is more useful is a simple, reliable, means of diagnosing of arterial occlusive disease. Systolic pressure of the ankle is measured by placing a pneumatic cuff around the ankle just above malleous. Doppler probe is placed over the posterior tibial artery and the pressure is measured. Then the Doppler probe is placed over the dorsalis pedis artery and the pressure is measured at this site. Sometimes in the absences of both dorsalis pedis and posterior tibial artery flow, flows over the peroneal collateral are assessed by placing the probe over the anterior to the lateral malleous. Because the ankle pressure varies with the central aortic pressure to normalize. These valves are ratio to the brachial blood pressure known as ankle brachial index. Valve of about 0.9 to 1.3 considered as normal any valve less than 0.9 indicates arterial stenosis. Medial calcification in the arteries renders it uncompressible makes the ankle brachial index errors, which occurs with diabetics. In that case pole test, will give rough estimate of ankle pressure that is elevating the foot against the bed in a vertical distance till the Doppler signal disappear, multiplying the distance in centimeters with a constant 0.735 results in pressure in millimeters in mercury[5].

Routine blood investigation such as total WBC count, differential count, hemoglobin percentage, packed cell volume, erythrocyte sedimentation rate, platelet count, blood grouping typing, renal function test such as blood urea, serum creatinine, serum electrolytes, C reactive protein, lipid profile, and Rhematological investigation such as antinuclear antibody, lupus antigen, Immunoglobin G, Immunoglobin M, was done in all the patients. Rhematological investigation was done the entire young patients to rule out vasculitis and a diagnosis of Thrombo Angititis Obliterans was entertained. Clinical criteria of Shinoya were followed. Those criteria as follows onset of disease before 50 yrs, smoking history, Infrapopliteal arterial occlusion, upper limb involvement or Phlebitis Migrans, absence of other risk factors other

than smoking for atherosclerosis.

The patient was routinely screen for their cardiac illness. They were screen with only resting echo for cardiac assessments. Categorization of the cardiac risk done based on the resting echo. With echo patients were assessed for the regional wall motion abnormalities status of the valve, their function capacity ejection fraction, thrombus inside the chambers of heart. Categorization was done as mild risk, moderate risk, and high risk with the resting echo.

Diabetic patient was assessed their fasting blood sugar, postprandial blood sugar valves. These patients maintained a blood sugar level within 180 mg with Insulin. These patients was maintained a strict blood sugar level in the intraoperative period and post operative period. All the patient treated with insulin before surgery, during the surgery and in the follow up period, because to have a better control of blood sugar in the pre operative, post operative as well as in the intraoperative period. Blood sugar values are monitored and treated accordingly

These patients after initial evaluation were subjected to angiographic procedure in the radiology suite. The radiological examination was done by the radiologist. Pre procedure preparation consists of preparation of the parts, adequate hydration with intra venous fluids normal saline[4,6], avoiding of drugs like metformin[4] which were known to induce contrast induced nephropathy, in risk renal compromised patients used N acetyl cysteine and consent for the angiographic procedure. Conventional radiological cut film technique was employed in the all patients in this group. Usually transfemoral approach was done for the entire patients in this group because of the presence femoral pulse in all the patients. Seldinger technique was used for the femoral punctures. Double puncture technique was used in all the transfemoral punctures. Guide wire was inserted and 4F dilator was used then usually 5F size sheath was introduced. Nonionic isotonic constrast was used in all the patients. Guide and multiple side holes pig tail catheter were introduced and flush Aortogram was taken with hand injections.

Then catheter was changed according to the need and availability which were pushed to the specific sites for the arterial visualization. Vitals were monitored in the radiology suite. After the completion of the procedure hand compression was given for a minimum of 5 minutes followed by compression bandage. Vital were monitored in the post procedure period in the wards with antibiotics, and heparin. All the patients after were monitored for complications of angiogram such bleeding, thrombosis in the post procedure period.

Anesthetic assessment was done and the risk categorization was done as per Goldman risk categorization method, taking into the investigation of the individual patient. Most of the patient underwent surgery under regional anesthesia with the intent to have post operative pain relieving by continuous epidural anesthesia. These patients also had spinal anesthesia along with epidural anesthesia. For earlier onset of action Spinal anesthesia, epidural anesthesia for prolonged and post operative pain relief. Under anesthesia both proximal and distal target vessel was exposed as described below for a specific artery for the specific patient.

EXPOSURE OF ARTERIES

Femoral artery exposure ; By vertical incision 2 finger breath lateral to the pubic tubercle starting at the level of inguinal crease extending 4 - 5 finger breath below and medial towards the medial aspect of knee. To gain full exposure of the femoral arteries the incision is carried towards above the inguinal skin crease cutting the lower fibers' of external oblique muscle. The artery lies just lateral to the bottom of the trough formed by the iliopsoas and pectineus muscles. After the skin incision is made and the superficial fascia opened, GSV may be seen divided between ligatures lymphatic lie medial and lateral to great saphenous vein. Dissection restricted to lateral to the lymphatics and lymph nodes and carried to the deeper vertical plane. Femoral artery is exposed by opening the vascular sheath which is extension of the deep fascia. The exposed artery is looped and the dissection carried proximal to expose the

branches of the femoral arteries (Common femoral artery, superficial femoral artery, deep femoral artery) are exposed

Popliteal artery exposure above knee; Medial exposure of the above knee, the incision is made by palpating the lower edge of the vastus medialis. Mostly the incisions were made on the great saphenous vein which was used as conduit. The incision is deepened to the deep fascia near it attachment of the medial intermuscular septum. This fascia was opened below this level where the popliteal artery leaves the adductor magnas tendon opening (hiatus). The popliteal artery is looped and controlled at this level. Care should be taken to avoid injury to the popliteal vein and saphenous nerve at this level

Popliteal artery exposure below knee; the skin incision was over the great saphenous vein, longitudinal incision beginning at the level of the knee posterior to the medial femoral chondyle to behind posteromedial edge of the tibia. Skin is incised; the fascia posterior to the tibia is incised. With retraction popliteal vessels can be seen in the superior aspect. In the inferior aspect are covered by soleus muscle on the tibia. For adequate exposure the soleus muscle upper fibers has to be cut with cautery. The popliteal vein over lies the popliteal artery in the lower part of the incision

Tibial peroneal trunk artery medial exposure; Similar to the popliteal artery exposure below the knee the incision is restricted to the lower part with extension at the lower end skin, fascia, muscle incised the popliteal vein retracted upward. Ligation of tributaries of the popliteal vein facilitate the exposure of the tibio peroneal trunk and dissection below lead to posterior tibial artery and proximal peroneal artery

Anterior tibial artery exposure anterolateral approach; Incision 1 or 2 cms lateral to the anterior edge of the tibial. It lies in between the tibialis anterior and extensor hallucis longus

muscle at a deeper plane. The anterior tibial vein lies over the artery and the vena comitantes are numerous care dissections free and ligating on the way to the artery and isolated for anastomosis

Anterior tibial artery at supramalleolar portion ;This is exposed the artery above the ankle and flexor retinaculum which passes between the lateral to extensor digitorum longus and extensor hallucis longus and medial to extensor hallucis brevis and tibialis anterior, these tendons are retracted artery will be seen readily

Posterior tibial artery mid segment; This portion of the posterior tibial artery just below the midpoint of soleus where it is thin. The incision at this point made and deepened soleus muscle cut with cautery and divided the vessel would be seen at this plane

Posterior tibial artery at infra malleolar level; With the supramalleolar incision at the distal extension of the mid segment exposure and following the posterior tibial artery distal and incising the ligament and the part or whole of the adductor hallucis brevis muscle. The over lying vena comitantes are ligated and the segment is isolated

Peroneal artery distal segment lateral approach; Incision was made over the fibula at the lower third or at the level were the artery was reformed in the angiogram. Skin incised and the overlying muscles were dissected. The periosteum of the fibula incised and elevated completely and circumferentially. Holes were drilled over the proposed point of division on both sides and the fibula is resected. After the removal of the fibula the periosteum incised, the underlying peroneal vessels exposed the vena comitantes and branches of the peroneal veins were dissected free and the supple peroneal artery for bypass isolated

Conduit

The conduit used was vein in most of the cases. Vein was harvested almost all the time from the same side lower limb vein. The vein was isolated from the incision for the artery even before exposure of the artery. After exposing the vein their branches were ligated on both sides with nonabsorbable suture material 2/0 or 3/0 nonabsorble sutures. If same side LSV was not available opposite limb LS vein was used. Very rarely upper limb vein and prosthetic graft used. The prosthetic graft used was PTFE graft. When graft was used special precaution were taken such using steri-drape sheet to prevent skin contamination. After exposing both the target vessels and graft were prepared, the plane at which the graft to be placed was planned. The tunneling was done in the plane already planned, mostly in the anatomical plane. Many times tunneling was done using Gore tunneler. When planned for subfascial plane Robert clamp used for tunneling that patient. Then systematic heparinisation was done with 5000 units of heparin. Clamping of the vessel done with vascular clamps using 11 blade arteriotomy was done on the target out flow vessel and inflow vessel. In almost all the patient the proximal anastomosis was done in end to side using 6/0 prolene or PTFE sutures CV6. Then the graft was brought to the distal target vessel in the plane which was already tunnelled plane. Graft prepared for the distal anastomosis after adequate flushing with heparin saline. Distal anastomosis was done in most of the cases in end to side using the same suture material as available and then sequential declamping was the done. In the patient were prosthetic graft was used were distal anastomosis was done with St Mary's boot[5] to improve the outcome of the procedures Perioperative anticoagulation. All patients Heparin postoperative, Low molecular weight dextran in patients with good LV function post operatively. All the patient had anticoagulation on discharge for 3 months with PT/INR was maintained at a level between 2- 2.5 by titrating their drug dose

Results with respect to outcomes of revascularization in the early post operative period

such as graft patency and limb salvage. Factors affecting outcome such as the etiology of the disease, co morbid factors, angiographic runoff score, conduit characteristics and their systemic illness. The score are given for the angiographic picture all the patient with poor run off with a single tibial artery out flow. Outcomes were in the in hospital period and in the early post operative period most in the 30 days. This patient was assessed by ankle brachial index even in the presence of palpable pulses. Duplex scan was used in the follow up period only in special occasions not as routine. Intra operative completion angiogram and intraoperative duplex scan were not used

RESULTS

86 patients out of the 217 patients who had bypass fit into the selection criteria as previously described. They form about 40% of the total revascularization patients

The mean age of patients was 42.5 +/- 14.5 years. The age varied between 25 yrs to 76 yrs. Most patients were in the age group 40 to 60 years(60.5%).

Age group	Number
20 – 29	2
30 – 39	18
40 – 49	28
50 – 59	24
60 – 69	10
70 – 79	4

Table 1: Age group incidence

206 patients were male forming the majority in the all revascularization group. 11 female patients were present in the all revascularization group. In the study group, 84 patients were male and 2 were female .

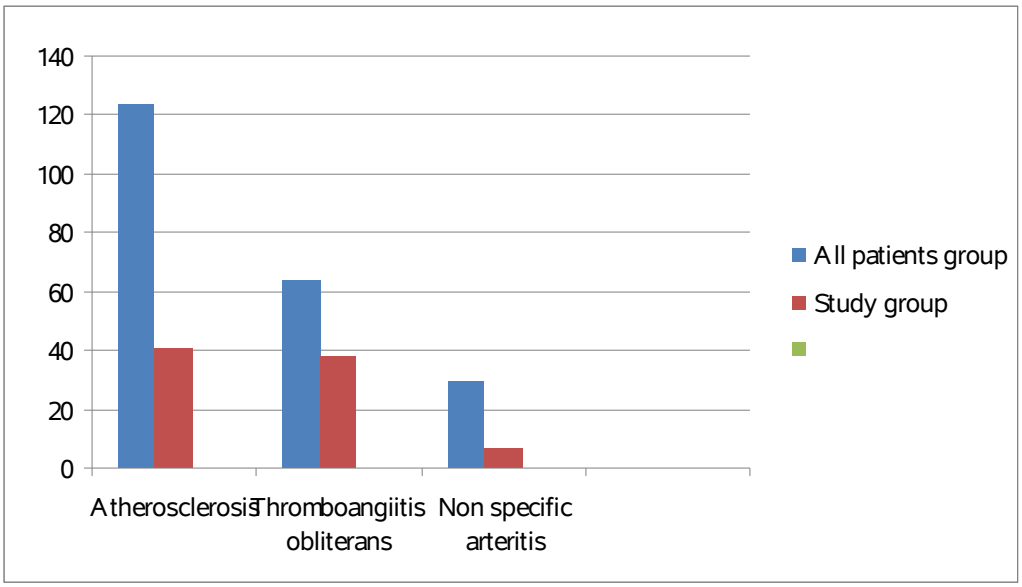
In both the groups' critical limb ischemia was the most common cause for the surgical intervention. Minor tissue loss in the form of toe gangrene was the most common indication for revascularization (69%). Non healing ulcers and forefoot gangrene formed about 30% of the patients. 11% of patients had ischemic rest pain. Functional limb ischemia formed only 1% of the patient group taken up for bypass.

Clinical presentation	Number
Toe gangrene	60
Non healing ulcer	18
Forefoot gangrene	7
Functional limb ischemia	1
Rest pain	10

Table 2: Clinical presentation - incidence

Out of the 217 patients who underwent bypass surgery for chronic limb ischemia, 124(57.15%) patients were diagnosed to have atherosclerotic occlusive disease, 64(29.49%) patients were diagnosed to have Thromboangitis Obliterans as per the clinical criteria of Shinoya, and 29(13.36%) patients were diagnosed to have arteritis. In the study group of 86 patients, 41(47.68%) patients who had bypass for single vessel disease belong to the category of atherosclerosis, 38 (44.18%) were diagnosed to have Thromboangitis Obliterans, and 7(8.14%) were diagnosed to have non specific arteritis. Atherosclerosis and thromboangitis

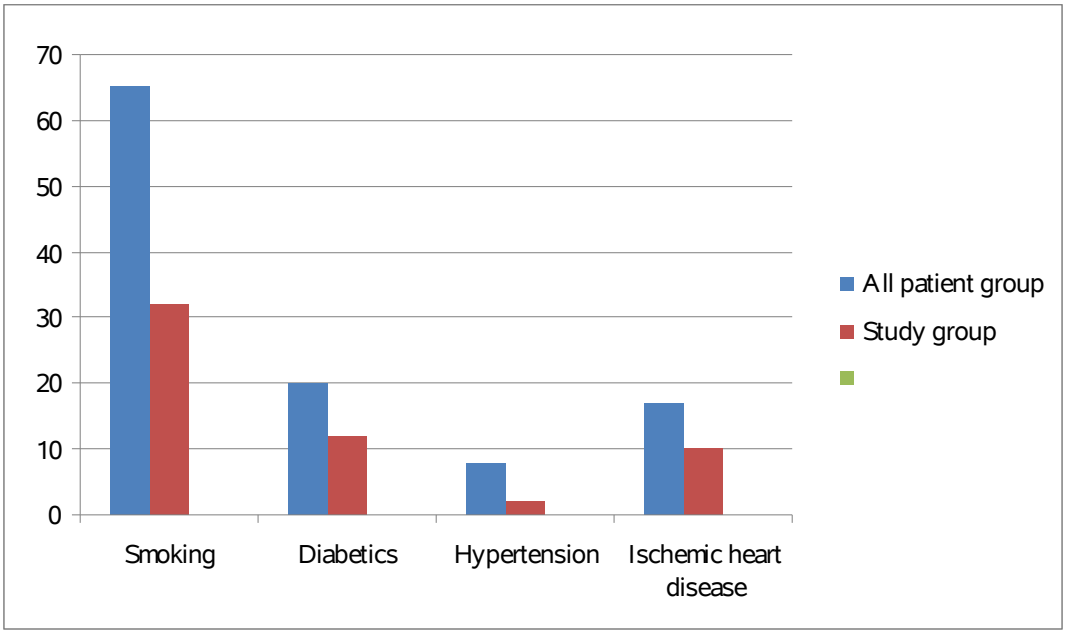
obliterans forms the major proportion of the patients who underwent revascularization for single tibial artery bypass. Critical limb ischemia was the indication for revascularization in single tibial revascularization group.



Incidence of different etiologies

Risk factors: Smoking was present in 65 patients, diabetes in 20 patients, hypertension in 8 patients, ischemic heart disease in 17 patients, and others (including cerebrovascular event, chronic renal failure and obstructive lung disease) in 8 patients in the all patient group. In the study group, 32 were smokers, 12 were diabetics, 2 were hypertensive patients, 10 were ischemic heart disease patients and 4 patients had other risk factors (2 patients had cerebrovascular accident, 1 patient had chronic renal failure , 1 patient had obstructive lung disease). Almost of all the patients had stopped smoking within the last 12 months. 80% to 85% of the patients stopped smoking within the last 3 months. 10% of the patients after stopping smoking changed to oral tobacco and snuff. Smoking history was present in all the patients, which was the single major risk factor in all the patients. 60% of diabetics were not on regular treatment. These diabetics' patients who had critical limb ischemia were diabetic for a prolonged period. The average period was a minimum of 7 years. Most of them were bare foot

walker or were wearing improper foot wear.



Risk factors	All patient group	Study group
Smoking	65	32
Diabetics	20	12
Hypertension	8	2
Ischemic heart disease	17	10
Others	8	3

Other risk factors include chronic renal failure patients, cerebrovascular accident patients, chronic obstructive lung disease patients, hypercoagulable patients. Other risk groups consist of small number of patients with various other risk factor, so they are grouped to separate group. The chronic renal failure patient in this group had elevated serum creatinine level of above 2mg/dL . This patients was non dialysis dependent in the CKD class III.

	Resistance value points	Posterior tibial	Anterior tibial	Peroneal
Total occlusion	3	0	0	0
< 50% occlusion	2.5	11	5	5
50-99% stenosis	2	3	2	4
20-49% stenosis	1	4	5	3
<20% Stenosis	0	21	13	10
Total		39	25	22

Table 4: Resistance value points of the study group

Angiographic run off score: As per the scoring system as prescribed earlier the angiographic run off score was done. Posterior tibial artery formed the most single arterial outflow in our series. In the posterior tibial outflow, 11 angiograms had less than 50% occlusion which carried a resistance value point of 2.5 and 21 angiograms had less than 20% stenosis in the length of the reformed posterior tibial artery which carried a resistance value point of 0. Reformed posterior tibial artery with stenosis less than 50% in its length,i.e, resistance value point of 1 was seen in 4. More than 50% stenosis in the reformed posterior tibial artery with a resistance value point of 2 was present in 3 patients' angiogram.

The Anterior tibial artery was next common vessel to be reformed in this series with 13 angiogram had less than 20% stenosis with a resistance value point of 0. Stenosis of less than 50%of the length in the reformed anterior tibial artery was in 5 angiograms which carried a

resistance value point of 1. In 2 angiograms more than 50% stenosis in the length of the reformed anterior tibial artery was seen, which carried a resistance value point of 2. Less than 50% occlusion of the reformed anterior tibial artery with a resistance value point of 2.5 was seen in 5 angiograms.

The peroneal artery was least common reformed artery in the series (n =22); less than 20% stenosis in the reformed peroneal vessel with a resistance value point of 0 was present in 10 patients' angiogram. Less than 50% length stenosis in the reformed peroneal vessel was present in 3 patients' angiogram which carried a resistance value point of 1. More than 50% stenosis in the length of the reformed peroneal artery was present in 4 patients' angiogram which carried a resistance value point of 2. Five patients' angiogram had a reformed peroneal artery with less than 50% occlusion in its length which carried a resistance value point of 2.5.

Scores were given and weightage points were added. 21 angiograms had a score of 9.5, and 9 angiograms had a score of 9.With a score of 8 there was 12 angiograms, and with a score of 7 there was 44 angiograms which form majority of the single vessel bypass group(i.e, having less than 20% stenosis in the outflow artery in the angiogram).

Total score	Numbers patients
9.5	21
9	09
8	12
7	44

Table 5: Runoff Scores of the angiogram in the study group

Femoro posterior tibial bypass was the most common type of bypass performed (n=31 patients). Femoro popliteal bypass forms the next common form of bypass with 30 patients. Femoro peroneal bypass was done for 13 patients while Femoro anterior tibial and popliteal to various tibial arteries bypass was done for 6 patients each.

Type of Bypass	Numbers(%)
Pop tibial	6(7)
Fem peroneal	13(14.2)
Fem ant tibial	6(7)
Fempost tibial	31(36)
Fempop	30(34.9)

Table 6: Types of bypasses in this series

Reversed saphenous vein was the most common conduit, used in 78 patients in our series. Other conduit were used in 8 patients, composite graft in 5 patients and prosthetic graft with vein cuff used in in 3 patients.

Conduit used	Total number(%)
Reverse saphenous vein	78/86(90.6)
Composite graft	5/86(5.8)
Prosthetic graft with a vein cuff	3/86(3.4)

Table 7: Conduit usage

In post operative period, 9 patients had wound infection in our series and graft thrombosis was found in 20 patients who had bypass surgery for single tibial artery outflow. Of these 20 thrombosed grafts 13 patients underwent redo bypass surgery. 10 of the 13 patients who underwent redo surgery had their grafts salvaged. 13 patients underwent major amputation, 5 patients were amputated inspite of a functioning bypass. They were amputated for extension of the gangrene, wound infection. Limb salvage rate at the time of discharge from hospital was 84.9%. 1 patient with failed bypass had a salvage of the limb at the time of discharge from the hospital, the rest had functioning bypasses.

Complications	Number of the patients
Wound infection	9
Graft thrombosis	20
Redo surgery	13
Redo bypass graft salvaged	10
Major amputation	13

Table 8: Complications in this series

Patients with thrombosed graft were assessed in detail.

The etiology was assessed. 8 patients had atherosclerosis and thromboangitis obliterans was present in 11. None of the arterititis group patient had any thrombosed graft.

The results of the thrombosed graft were studied according to the angiographic runoff score. Posterior tibial artery bypass with respect to resistance value point: 5 out of 21 (23.8%) posterior tibial artery bypasses were occluded which had a resistance value point of 0 with less than 20% in the length of stenosis. 3 of 4 (75%) posterior tibial artery bypasses with a resistance value point of 1 that is more than 20% – 49% length of stenosis in the length was thrombosed. 3 of 11(27.27%) the posterior tibial artery bypass with resistance value point of 2.5 that is less than 50% length of the artery occluded had a failure.

2 of the 13 (15.38%) anterior tibial artery bypasses surgery with a resistance value point of 0 that is less than 20%of the length of artery stenosis failed. 3 of the 5 (60%)anterior tibial artery bypasses with resistance value point of 2.5 had failure. 4 of the bypasses to the peroneal artery had a failure. of which a resistance value point of 0 had 2 failures out of 10(20%) patients and with a resistance value point of 2.5 had 2 failures out of 5 (40%) patients

	Resistance value points	**Pta**	**Ata**	**Per**	**Total no. of failed graft**
Total occlusion	3	0	0	0	
Occlusion < 50% length	2.5	3/11	3/5	2/5	8/21
50 – 99% stenosis	2	0/3	0/2	0/4	0/9

20 – 49% stenosis	1	3/4	0/5	0/3	3/12
< 20% stenosis	0	5/21	2/13	2/10	9/44
Total no. of graft failures		11/39	5/25	4/22	20/86

Table 9: Failure of graft according to resistance value points

Angiographic score of 9.5 had 8 failures of 21 bypasses which had 38.09% failures rates. Angiographic score of 8 had failure of 3 out of the 12 similar score. 9 of the 44 (20.45%) bypasses failed with a score of 7

Score	Number
9.5	08(38.09%)
9	0
8	03(25%)
7	09(20.45%)

Table 10: Angio graphic runoff scores in the failed graft

Of the femoro posterior tibial artery bypasses 9 out of the 31(29%) had a failure. In the femoro peroneal artery bypasses of 13, 4 bypasses had a failure (30%). Femoro anterior tibial artery bypasses had 3 failures in 6 (50%) bypasses, femoro popliteal artery bypasses failed in 2/30 bypasses (6.7%), and popliteal to tibial bypasses failed in 2 of the 6 (33.3%) bypasses.

Type of bypass	Number of failed grafts	Number of procedures
Fem peroneal	4	13
Fem ant tibial	3	6
Fem posterior tibial	9	31
Fem popliteal	2	30
Pop tibial	2	6

Table 11: Failures of graft according to bypasses

Conduit used in the bypass was also studied. 78 saphenous vein grafts was used of the 86 bypasses (90.7%). 8 of the 86 (9.3%) bypasses used other graft. Of the 8, 5 were composite graft and 3 were cuff vein used.

Conduit used	Total number in this study group	Number of Failures in the group(%)
Reverse saphenous vein	78/86	15/78(19.2)
Composite graft	5/86	2/5(40)
Prosthetic graft with a vein cuff	3/86	2/3(67)

Table 12: Conduit usage

Saphenous vein grafts failed in 15 patients. A seemingly healthy vein was used in 7 bypasses while 8 thrombosed bypasses used phlebitic saphenous vein. Of the 3 vein cuff used for bypasses, 2 (67%) bypasses. 2 of the 5 composite graft patients failed (40%).

All the thrombosed graft studied posterior tibial outflow vessel bypasses femoro posterior tibial bypasses was 9, femoro popliteal bypass was 1, and popliteal to posterior tibial bypass was 1. Anterior tibial artery flow out bypasses was 7 and 3 bypasses had failures, femoroanterior tibial bypasses had 2 failure and 1 popliteal to anterior tibial artery bypasses had failure. Peroneal artery outflow bypasses had 4 failures, 3 cases failures in the femoroperoneal bypasses, and 1 femoropopliteal bypasses had failure

In the redo surgery of the thrombosed graft was analysed in 5 of the cases there was a technical problem which was overcame in the redo procedure and in other 5 cases no cause was identified

All the patients who had thrombosed graft had a major amputation except one patient. 5 patients had amputation in spite of graft being patent. In this series, single tibial artery

revascularization patients had limb salvage which forms about 84.9%. 1 patient with failed bypass had a salvage of the limb at the time of discharge from the hospital.

3 patients died in this series of 86 single tibial artery outlflow bypass surgery patients. 2 patients died in the immediate post operative period within 72 hrs. Acute myocardial infarction was the cause of the mortality in all 3 patients. Both the patients had previous history of myocardial ischemia with poor LV function. Both these patients were diabetic patients, systemic hypertension. One of the patients had quit smoking within 10 days of the surgery. One of the patient developed acute myocardial infarction in the intraoperative period and was managed in intensive post anaesthetic care unit where he died 24 hrs later. The other patient developed myocardial infarction 24 hrs post operative period died within 1 hour. 1 patient had no risk factors in the pre operative evaluation. Mortality of this series was 4%.

DISCUSSION

Average age of the patient undergoing bypasses in this series was 42.5yrs with range from 25to 72 yrs. Mean age of revascularization procedure in other series was 70 yrs. [7, 9.] The age range of the patient in the other series with single tibial vessel outflow was between 56yrs to 96 yrs. This difference in the average age might be due their etiological pattern of disease, which was predominantly atherosclerosis in their patients, whereas in this study there was large number of thromboangiitis obliterans. Thromboangiitis obliterans is not common in their population.

Out of the 217 patient in the all bypass group there was 11 female patients with males forming the majority of the revascularization patients, in the study group of 86 patients, only 2 were female and the remaining patients were male. In other series of lower limb revascularization there were female patients in the range of 20%[2]to 35%[7]. The reason for this poor representation in the revascularization series might be due lower incidence of smoking in

the female. Incidence of thromboangiitis obliterans was higher in the males, whereas it has been only scarcely reported in females.

Critical limb ischemia with minor or major tissue loss was the most common mode of presentation in our series which was about 78%, non healing ulcer in another 9% of the patients and critical limb ischemia with rest pain in 11% of the patient. Functional limb ischemia was a mode of presentation in less than 1 % in all patients as well as in the study population. But revascularization was done to patients with critical limb ischemia and 2 patients with functional limb ischemia in the study group of single tibial artery bypass. In all limbs revascularization group in our centre, critical limb ischemia was the major criteria for which the patients underwent revascularization procedure in our centre. Minor tissue loss was the largest group of patients who had revascularization procedures. Functional limb ischemia patients had revascularization in about 2%. The reasons for this late presentation of the patients to the vascular surgery was late referrals to the department, the patient seeking medical attention only in the advanced stage, sometimes it might be due to that many patients with critical limb ischemia were given priority over functional limb ischemia. Often the symptom of claudication was ignored and attributed for many other reasons most of the time, most of them present to other medical specialist before presenting to the department of vascular surgery for their illness. Critical limb ischemia and rest pain only made the patients seek medical attention. In other studies of tibial artery revascularization gangrene was the mode of presentation in 32%- 44%[7, 10]. Rest pain was the symptom in 25%- 36% of the patients who had revascularization procedures. Functional limb ischemia was the indication for revascularization in 16%-43%[7, 10]. Because of the increased aware about the disease in the patients and the prevalence of the disease is higher in their population. Improved medical care for their population might be another reason.

Atherosclerotic occlusive disease is the most common etiology for their patients more than 95% of their patients and etiology thromboangiitis obliterans was almost non existent in their series and other etiology was small percentage in their series. Indian were more prone to thromboangiitis obliterans because of the disease is more common among the low socioeconomic peoples who smokes beedi which has an unprocessed tobacco in it. The prevalence is about 14%-50%. Arterial disease in the diabetic patients in Indian population has also been quoted at a lower rate of only 2%-4%.

The angiogram was assessed and the angiograms with single tibial artery were selected. To standardize the angiogram a scoring system was adapted. Rutherford had suggested the first scoring system in 1986 even thou simple, it does not correlate with the outcome perfectly. Rutherford suggested revision in 1997 that overcome the problem in the first scoring system which was adapted by the SVS/ISCVS. The scheme grades both the degree of occlusion and the relative contribution to outflow of each run off vessel, from 0 to 3, and then adds 1 to the product of these two grades, resulting in a decimal scoring system that assigns 1 to a widely patent runoff and 10 to an isolated, blind segment with no major vessel runoff. In this scheme, higher values correspond with higher resistances so that Resistances in series and in parallel can be graded[2, 3]. Although calculation of the score based on this system might be complex in some cases, it is simple in most others.

Weight age points

Distal anastomosis	**3**	**2**	**1**
Popliteal above-knee Popliteal below-knee	Distal popliteal		**Anterior tibial** Posterior tibial Peroneal

Anterior tibial Posterior tibial Peroneal Pedal/inframalleolar		Distal tibial Distal tibial Pedal runoff	Pedal arch Pedal arch Collaterals to anterior and posterior tibial arteries

Resistance value points of runoff arteries (total of three units)—occlusion

Degree of occlusion	**3**	**2.5**	**2**	**1**	**0**
Major runoff vessels	Occluded throughout of length	Occluded less than ½ stenosis visible collateral	50% to 99% greatest stenosis	20% to 49% greatest stenosis	Less than 20% greatest stenosis

EXPLANATION

1. Three "weightage units" are divided among the major runoff arteries in the segment below or beyond the terminal anastomosis, according to their normal relative contribution to runoff or outflow. The infrapopliteal arteries there are three more or less equal runoff arteries, are assigned one unit each. A normally single vessel outflow may receive all three weight units, or these units made individually assigned to each of its runoff vessels (e.g., the tibial and peroneal arteries) depending on which is considered to present the greatest degree of occlusive disease and resistance to runoff (i.e., the highest calculated runoff score). Weighting units for each lower extremity artery shown as in the table

2. A "resistance value" is also assigned to each outflow artery, with a maximum

resistance value of 3. As shown in the bottom table, three "resistance" units are assigned to a vessel that is totally occluded throughout its length, two units to one with a 50% to 99% stenosis, one unit for a 20% to 49% stenosis, and none if widely patent.

3. The sum of the products of the weightage unit multiplied by the resistance value for each major runoff artery is added to a base "resistance" of one, in recognition of the fact that even a widely patent distal bed offers some resistance. This creates a decimal Runoff resistance score, in which a blind segment carries a value of 10 and a widely patent system, is scored as 1. The contribution of each occlusive lesion to runoff resistance depends on its artery's relative weight. Thus a 60% stenosis of a posterior tibial artery below a below-knee femoropopliteal bypass graft would have a resistance value of (2 × 1) 2 points.

4. An occluded posterior tibial artery and a 60% stenosis of the anterior tibial origin would receive 2 out of 3 points, much like previous 1 to 4 grading schemes. Bypassing to a single tibial artery or the dorsalis pedis are examples of a normally single-vessel runoff. Because it is unlikely that this procedure would be performed to a vessel with a hemodynamically significant stenosis, runoff will normally be determined by the pedal arch, and the 0 to 3 score offered for this above can be applied. Arbitrarily, 1 point would be added to this score in bypass grafts to a peroneal artery, in recognition of its lack of direct connection with the pedal artery circulation. These simpler alternatives are offered as a compromise, for use when runoff grading is included in the analysis along with other risk factors mainly to characterize overall case severity in reported series..

Since this study was to assess the outcome of the single tibial artery outcome the scores were 7 to 9.5 in the patients. 44 patients in this series had a score of 7 which had a resistance value point of 0 with less than 20% stenosis in the reformed tibial artery. 21 patients had a score of 9.5 which had resistance value point of 2.5, poorer out flow in the single tibial artery

revascularization series with 50% occlusion of the length of the reformed tibial artery. Other scores in this series were 12 patients had a score of 8 a resistance value point of 1 with more than 20% upto 49% stenosis in the greater length of the reformed tibial artery and 9 patients had a score of 9 with a resistance value point of 2 with more than 50% stenosis of the reformed tibial artery.

Biancari et al have previously examined the ability of the runoff score to predict hemodynamic success, immediate graft patency, and overall graft patency[11, 12]. The patients in their series had a median runoff score of 3.5 (range, 1-9). Although they demonstrated that the runoff scores in this range predicted hemodynamic success after infrainguinal bypass, these scores did not predict immediate or overall patency. A subgroup of grafts with widely patent outflow (runoff score, 1) did demonstrate excellent patency and limb salvage rates compared with all other runoff scores. Several other series have reported similar results using the SVS/ISCVS runoff score or modifications thereof. This series focuses on grafts with a single tibial artery outflow in the supragenicular and infragenicular positions as defined by the SVS/ISCVS criteria. Even at this single tibial artery outflow, there was no difference in patency or overall patient survival rates when compared with grafts with patent outflow in the early post operative period. The patient with total score of 9.5 revascularised tibial artery outflow patient had thrombosis in 38% of the patients.the patients with total score of 7 revascularised tibial artery outflow patient had thrombosis in 20% of the patients

Seeger et al have used a modified SVS/ ISCVS runoff score to demonstrate results similar to those of our study. Their series separated 210 patients with tissue loss into those with “good runoff” and those with “bad runoff,” with an arbitrary runoff score cutoff of 6 for popliteal bypasses and a runoff score of 5 for pedal bypasses[14]. Bad runoff predicted death, limb loss, and amputation despite a patent bypass. Whereas the limb salvage findings were

similar to this series. The study by Seeger et al similar to this series because it included only patients with tissue loss and because all bypasses were performed using autogenous conduits. No difference between poorer outflow and patent out-flow groups was noted with distal anastomoses at the infrageniculate level. Above-knee bypasses to poorer outflow vessels certainly offer a less direct reconstruction with a greater portion of the limb requiring collateral circulation. Because of the retrospective design of the current study, differences in patient characteristics between the good and poorer outflow groups with respect to age, smoking, hypertension, could influence our results. Results leading to inferior outcomes, the lower incidence of smoking in patients undergoing blind bypass could skew the results for the group favorably.

With the increased complexity of infrainguinal bypass procedures performed in the current era, the role of severely compromised outflow in determining outcomes has not been fully evaluated. Hemodynamic measurements of outflow resistance provide another potential measure that may predict bypass outcomes. Peterkin et al examined the correlation between angiographic runoff scores (particularly with appropriate weighting of individual vessels) and intraoperative measures of hemodynamic resistance[15]. If this relationship is accurate, single tibial artery outflow with score more than 8 such as that examined in the series should be associated with the highest outflow resistance values. Although this hemodynamic measurement was not performed in this series, our results are consistent with most studies examining the effects of outflow resistance on graft patency. Studies performed by Peterkin et al, Cooper et al, and others have failed to demonstrate hemodynamic outflow resistance as a predictor of infrainguinal graft patency[15, 16]. Although Ascer et al maintain that outflow resistance does predict graft patency; single artery outflow may not translate directly into high outflow resistance. Ascer et al's series also included a preponderance of prosthetic bypass grafts. These may have inferior patency in high resistance beds compared with autologous

bypass grafts, which can remain patent despite high outflow resistance ISCVS runoff score[17, 18]. Although this score accurately incorporates anastomotic site, degree of occlusion, and pedal arch integrity, the use of this scoring system has not consistently predicted graft patency, limb salvage, or survival. All previous studies have attempted to stratify patients across the entire range of runoff scores, but only a few studies have focused on the ability of the worst score (SVS/ ISCVS runoff score, 7-9.5) to predict outcomes.

The ability of these poor runoff bypass grafts to remain patent, particularly in an infrageniculate location, may reflect a greater importance of conduit quality or inflow. Hemodynamic measurements of outflow resistance might provide another potential measure that may predict bypass outcomes although hemodynamic measurement was not done in our study poorer outflow did not predict graft patency; it may be marker for limb loss in follow-up study Tena R. Desai et al series[1]. Several and by the widespread occurrence of disease previous studies have failed to demonstrate an overall correlation between angiographic runoff score and limb salvage. However, these studies did not include substantial numbers of patients with compromised outflow.

Primary graft failure in the series was 19 patients in the single tibial artery bypass in a total of 86 patients which was 23% in the early post operative period. In similar study by Tina R. Desai, et al in Infrainguinal Bypass with Severely Compromised Outflow they found a primary graft failure in 13% of their patients in both group of 351 patients of all revascularization and of 72 patients with poor runoff score[1].

James M. Seeger et al reported forty-six graft failures occurred in 45 patients (21.4%) in 210 patients who studied about the potential predictors of infrainguinal bypass surgery[14]. Of 210 all patients' revascularisation group only 131 patients had a bypass to an infragenicular artery with 43 patients had a bypass to single tibial vessel. Of the poor distal runoff score

patients graft failure in about 41.8%. This higher incidence of graft failure was due to chronic kidney disease patients and higher incidence of diabetic patients in the study group.

Conduit used in most of the revascularization was saphenous vein ipsilateral side. We used veins without obstruction with fair amount of distensibility. We used a few diseased veins in our series, as no other conduit was found suitable. Usually any veins with less than 2mm diameter were not used. Conduit plays important role in the functioning of the graft. Graft thrombosis in a vein is commonly caused by a reduction in graft blood flow. Poor graft flow leading to thrombosis occurs as a result of mechanical defects due to technical errors in the construction of bypass, improper patient or procedure selection, use of poor quality vein, small caliber vein, severely damaged vein conduit. Davidson and colleagues[19] observed in a thrombosed vein graft, technical factors may not be identifiable and also found that in many patients with unexplained graft thrombosis had a previously undiagnosed hypercoaguability disorder. Gentile et al[20] demonstrated that tibial reconstruction with alternative vein sources required revision in about 30% of bypass grafts, as opposed to 12% of bypass grafts in greater saphenous veins. They concluded that comparable secondary patency rates can be obtained by using alternative vein sources compared with greater saphenous vein. In Darling et al study[21], veins less than 3.4mm diameter had a revision bypass in 22% compared with vein of diameter more than 3.4mm had revision in only 8%of the patient and concluded that even in patients with limited venous conduits, the overall outcome as measured by means of limb-salvage rates was excellent, and this may be because of diligent postoperative surveillance, aggressive surgical intervention, and the use of unconventional forefoot amputations. Ishii Y**,** reported Minimum internal diameter of the greater saphenous vein is an important determinant of successful femorodistal bypass grafting that is independent of the quality of the runoff[22]

David K. W. Chew,et al confirms the superiority of the great saphenous vein over single

segment arm vein and composite vein grafts for autogenous infrainguinal arterial reconstruction. In addition to improved patency, technical expediency, and less frequent reinterventions favoring use, their experience suggests that the long-term outcome of the contralateral limb was not compromised with their approach, even among patients with diabetes[23]. Contralateral great saphenous vein is the preferred alternative conduit for most patients without adequate ipsilateral great saphenous vein for infrainguinal arterial reconstruction.

When saphenous vein is not available prosthetic graft is used commonly PTFE graft is of the choice. PTFE graft is used with a vein cuff which improves the long term patency. Stonebridge et al in his randomized control study PTFE graft with vein cuff versus without cuff reported a 2 years patency of 52% versus 29%. Clearly indicated when PTFE graft used for the below knee bypass surgery vein cuff was recommended[24]. Taylor patch was compare with St. Mary's boot reported equivalent results. In this series miller cuff was used in the 5 patients who underwent revascularization procedures which has an immediate failure of 60%. Patients might be due to the poor quality of veins used in them however other studies poor outcomes in requiring revision in about 20% of the patients[25].

Graft disruption as the result of wound breakdown and graft exposure was the cause of graft failure during the postoperative period, and graft stenosis was the cause of graft failure. The bypass graft conduit was saphenous vein in 8 of the grafts that failed, vein cuff was used in 3 and composite graft and vein in 5. The bypass grafts that failed were to the popliteal artery in 2 patients, to the infrapopliteal arteries in 17 patients. Successful graft revision was possible in 10 patients whose grafts failed during the postoperative period. All the successfully revised grafts were constructed with LSV harvested from the contralateral limb vein

Placing the venous bypass graft in the anatomic position may be protective in patients at

risk for wound breakdown. This was the technique most commonly used in the study, and, despite this approach, a high number of patients had wound complication. Wound infection was a cause of graft failure in 5 revascularisation procedures in the post operative period. Tina.R. Desai reported wound infection in 11% of the revascularization patients and was the cause of graft failure in 8% patients. Graft failure during the postoperative period appeared to be caused by poor vein graft, vein cuff and composite graft[1]. This might be that these procedures in the hospital and the patient selection for these procedures were poor candidate for revascularization procedures. Although the exact cause of graft failure was difficult to determine in these patients. Size of the vein graft was a determinant of the graft failure. The type and the size of the venous conduit used for these bypass grafts was found to influence graft failure, although the short length of the follow- up period and the small number of patients studied likely influenced these results.

Postoperative mortality in the study was primarily caused by cardiac complications. This is not surprising considering the high incidence of coronary artery disease in patients with severe peripheral arterial occlusive disease.[26] Unfortunately, it will likely be difficult to reduce the incidence of cardiac complications in these patients with diffuse atherosclerosis because previous studies have shown that routine extensive cardiac evaluation does not result in better overall postoperative survival[27]. Furthermore, the mortality rate and the incidence of cardiac complications after primary amputation are at least as high or higher than after bypass grafting procedures,[28] and this is particularly true in patients with end-stage renal disease who undergo amputation.

Routine intraoperative or early postoperative duplex ultrasound scan graft imaging as advocated by Bandyk et al[29] potentially could have reduced this seemingly high rate of vein graft failures. Only 5 patients had a completion angiogram in this series of single tibial artery

disease either because completion angiogram was not a routine. Intra operative duplex examination was not done as part of routine revascularization protocol. Routine intraoperative examination reduces the early graft thrombosis due technical fault. Intra operative completion angiogram is the gold standard. Courbier et al[30] detected significant technical problem in 4.3%. Of the patients with bypass graft who were studied, found a technical problem in 2.2%. Those problems include emboli, thrombosis, twisted and kinked grafts, distal anastomostic stenosis, and intimal flaps. Mills and coworkers[31] found 8% of the graft have technical problem detected by intraoperative angiogram. Completion angiogram after infra inguinal revascularization provides valuable information about the state of the conduit, the distal anastomosis, the runoff circulation and the main stay for the confirmation of technical adequacy. Infra operative angiogram might have helped to improve the early post operative follow up in this series.

Kretschmer et al, in a prospective randomized trial found that long-term anticoagulation therapy with dicumoral improved femoropopliteal bypass graft patency rates primarily for patients who underwent arterial reconstruction for limb salvage (those most likely to have poor runoff).Postoperative anticoagulation therapy with heparin and aspirin followed by long-term anticoagulation therapy with warfarin and aspirin were found to improve the duration of graft patency and the limb salvage rate after autogenous vein infrainguinal bypass grafting for patients at high risk for graft failure[32]. Rosenthal et al, in a post hoc analysis demonstrated that a subgroup of patients at high risk for graft failure were the ones most likely to benefit from long-term anticoagulation therapy[33]. In contrast, Timur P. Sarac findings contradict the results from the other randomized studies on the use of long-term anticoagulation therapy after infrainguinal arterial reconstruction in which duration of graft patency and the limb salvage rate were found to be equivalent in patients who were treated as compared with the control group[34]. 30% of the patients who were randomized to long-term anticoagulation therapy in the study by Johnson et al had stopped taking warfarin or had a subtherapeutic INR at the time of graft

failure. Although McCollum et al demonstrated that aspirin alone did not alter infrainguinal vein graft patency rates, immediate graft platelet uptake is inversely correlated with 1-year graft patency rates and patients whose platelets aggregate more readily are more likely to suffer graft failure. In addition, warfarin combined with aspirin has been found to be more effective in preventing long-term prosthetic valve thromboembolic complications as compared with warfarin alone, without increasing the risk of bleeding complications[35]. Anticoagulation therapy improves bypass graft patency and limb salvage in patients at high risk for bypass graft failure who undergo infrainguinal vein bypass grafting. Hence all the single tibial artery bypass patients had heparin in the post operative period and followed by oral anticoagulation with aspirin and their PT/INR was maintained at 2-2.5 range.

Many factors, such as initial symptoms, degree of occlusive disease, and availability of appropriate bypass graft conduit influence the results of lower extremity arterial reconstruction. Furthermore, despite overall good results with arterial bypass grafting procedures, outcome in an individual patient may be poor. In this series of patients with significant infrainguinal arterial occlusive disease with tissue loss, initial outcome after infrainguinal venous bypass grafting was acceptable; initial limb salvage rate was 84.6%. Although the goal of limb salvage can be achieved in most patients who undergo infrainguinal bypass grafting for tissue loss, careful patient selection is necessary to limit the number of patients who will have limited or no benefit from these procedures. James M. Seeger reported a limb salvage rate of about 81% in his series of infra inguinal bypass surgery. Run off score is the strongest predictor of long term limb salvage in infra inguinal bypass[27].

The predictors of survival with limb salvage with multivariate analysis in his study were runoff score, anticoagulation therapy and diabetes mellitus, and survival with limb salvage and a patent bypass graft was not predicted with runoff score alone. Diabetes mellitus

is a risk factor for amputation because of progressive tissue loss despite a patent bypass graft and for wound breakdown leading to graft disruption which uniformly led to amputation in the present study. Diabetes mellitus has not been shown to affect bypass graft patency, so it is not surprising that survival with limb salvage and graft patency was not predicted by the presence of diabetes mellitus.

The severity of ischemia is an important predictor of postoperative amputations and death rates. There was also a correlation between the severity of preoperative leg ischemia and the postoperative amputation rates, but the degree of preoperative leg ischemia did not affect mortality rates. The severity of ischemia is an important predictor of postoperative amputations and death rates[36].But in our series of single tibial artery revascularization the degree of ischemia to a larger extent does not influence the outcome of the patients in the early post operative period. Although advanced ischemia to involve major tissue loss with other co morbid conditions such diabetic, ischemic heart disease had an influence in the early outcome of the patients. These patients with major tissue loss with diabetics have complication such as wound breakage and graft failure and thereby limb loss. So major tissue loss with diabetic patients have higher rate of graft failure and limb loss in spite of graft functioning.

Infusions of dextran 40 produce both antiplatelet and volume expansion effects. These effects have been found to protect early patency in lower extremity bypasses under selected circumstances[37] such as poor run off in angiogram. Dextran 40 reduces spontaneous and agonist-induced platelet aggregation as well as the surface expression of markers of platelet activation in Peripheral Artery Disease patients. The antiplatelet effect may be of benefit to patients undergoing vascular surgical procedures where thrombosis is a significant risk. Dextran 40 was useful in patients with difficult bypass.

Delays in referral, investigation, and treatment of CLI can reduce the possibilities of

successful treatment. Unfortunately, patients often are referred to a vascular surgeon after gangrene has developed and spread. We should evaluate all CLI patients with the goal of performing a revascularization. The decision-making process for patients with CLI is often difficult; we should treat CLI patients in hospitals with adequate resources to ensure an optimal treatment without undue delay that can jeopardize the ischemic leg. Because the goal of CLI treatment is to avoid amputation, a main measure of treatment efficacy is the limb salvage rate.

In summary, this study suggests that infrainguinal bypass with single tibial artery outflow yields patency and survival rates comparable with bypass performed with patent outflow. However, poorer outflow does remain a marker for subsequent limb loss, and when the bypass terminates above the knee. Infrainguinal bypass with single tibial vessel outflow yields acceptable patency and survival rates. Patients with poor conduit quality, active tobacco use and LV dysfunction have poorer clinical outcome. Careful consideration is warranted prior to infrainguinal bypass grafting in these situations. Nonetheless, availability of only a poorer outflow vessel should not preclude aggressive attempts at limb salvage in appropriately selected patients.

CONCLUSION

- Infrainguinal bypass with single tibial vessel outflow yields acceptable patency and survival rates.
- Patients with poor conduit quality, active tobacco use and LV dysfunction have poorer clinical outcome
- In patients with single vessel runoff, the angiographic runoff score does not affect early outcome.
  - It is however a marker for subsequent limb loss.
  - It should not preclude aggressive attempts at limb salvage in selected patients.

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